Subscale Design of an NTP Engine Exhaust Containment System

Completed Technology Project (2014 - 2014)

Project Introduction

In order for NASA to enable safe manned space flight travel to reach destinations such as Mars, and beyond, advance propulsion technologies, like Nuclear Thermal Propulsion (NTP) will be required. Ground testing for engine qualification will be required as part of the process for novel NTP rocket engines development. Although NTP engines have been tested in the past, methods that were used (open air NTP exhaust) are not acceptable in today's regulatory environment. Currently, there is not an acceptable ground test method that has been successfully operated and safely demonstrated which could scale up to the power levels anticipated from NTP engines currently under consideration. One favorable method is based on a total containment NTP exhaust system concept, which has been documented as a viable option reported by the ARES Corporation on Nuclear Thermal Propulsion Ground Test Facility (2006) concept definition; the total containment option was recommended as one of three possible ground test facility possibilities. There is potential opportunity for Stennis Space Center (SSC) to demonstrate operation of a non-nuclear subscale implementation of the total containment concept for a NTP. This goal of this project is to develop preliminary design elements and integrated systems for making a proof-of-concept technology demonstrator subscale system for a non-nuclear rocket engine. This subscale system would serve as a non-nuclear test bed which could eventually be used to help optimize design, built, and test systems required for operating a safe, environmentally acceptable NTP ground test facility.

A total containment NTP exhaust system has been conceptually engineered, however, since this a completely novel approach to address the numerous issues associated with fully containing exhaust from and NTP rocket engine test, to date, no experimental proof-of-concept has been conducted for this innovative technological approach. Therefore, to demonstrate proof-of-concept, this project will develop the preliminary engineering design for a subscale demonstration for a full exhaust containment system. To accomplish this, a closed system of ducts and vessels will be used, and liquid oxygen (LOX) will be injected into the hot hydrogen exhaust to convert it into steam, which will then be condensed and stored as liquid water. Any particulates present, due to sub-optimal engine operation, will either be caught in a particle trap, or end up in water storage vessels, which will store the water indefinitely until fission products either decay, or are filtered, and ultimately can be safely discharged. Gaseous oxygen and any noble gas fission products will then be condensed in a cryogenic heat exchanger and stored in a chilled jacketed Dewar as LOX, and any residual noble gasses, if present, will solidify and can remain stored in the Dewar indefinitely, until the gases have decayed and can safely be released. In this way, all possible fission products that could result from an NTP engine ground test would be captured and stored, and subsequently evaluated and assessed for radioactive contamination and handled accordingly, as needed, over an indefinite period of time.

The components for this system will incorporate additional design elements

Subscale Design of an NTP Engine Exhaust Containment System

Table of Contents

Project Introduction	1
Anticipated Benefits	2
Organizational Responsibility	2
Project Management	2
Primary U.S. Work Locations and Key Partners	3
Images	3
Technology Maturity (TRL)	3
Technology Areas	3
Stories	4

that are currently in development that will be integrated with the overall design concept. Valuable data collected from these separate design components would then feed into the development cycle of a full scale NTP ground test facility based on outcomes of the subscale concept. The subscale technology demonstrator could ultimately serve as a non-nuclear test bed for NTP ground test facility system components and instrumentation, and would prove to be an invaluable resource for use during the design for a full scale NTP ground test facility. The goal of the project is to better prepare and align NASA SSC for successful participation in developing safe, affordable NTP technologies for future manned space flight travel.

Anticipated Benefits

The subscale design of an NTP engine exhaust containment system directly benefits NASA future manned mission to MARS by developing a ground test facilities that safely and affordably support NTP technologies.

The subscale design of an NTP engine exhaust containment system directly benefits NASA unfunded missions and planned mission, by enabling testing of advanced propulsion technologies that need to be developed now, to safely and affordably send a manned mission to Mars by 2033, and beyond.

Benefits to the commercial space industry will be similar to those that would be provided NASA; a innovative method to safely and affordably ground testing a NTP rocket engine, that would fully contain the exhaust, thereby significantly limiting fission product exposure, would be enabled.

Benefits to other government agencies will be similar to those that would be provided to NASA; an alternate innovative means to ground test a NTP rocket engine, which meets current environmental and safety standards, and considerably limits fission product exposure from nuclear exhaust. Applications of this novel technology could be used by the Department of Defense for advance propulsion techniques on submarines. Additionally, the Department of Energy or the Environmental Protection Agency could potentially implement this technology as a new way to treat nuclear waste.

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Stennis Space Center (SSC)

Responsible Program:

Center Innovation Fund: SSC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Ramona E Travis

Project Manager:

Jody L Woods

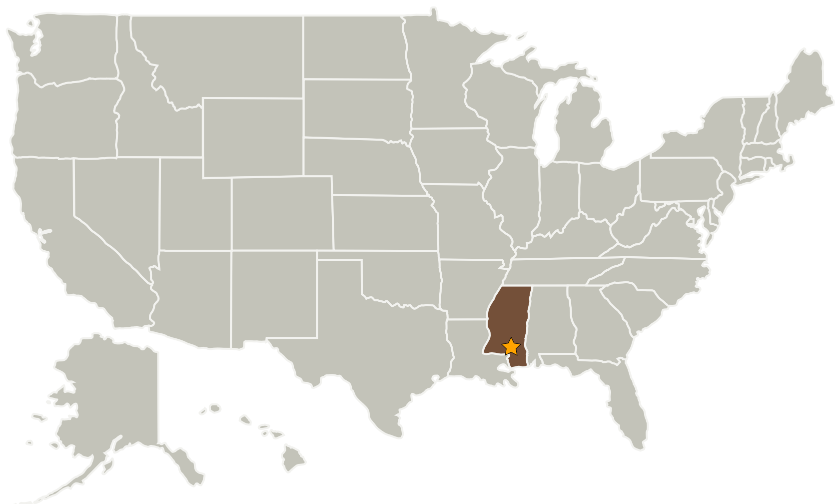
Principal Investigator:

Jody L Woods

Subscale Design of an NTP Engine Exhaust Containment System

Completed Technology Project (2014 - 2014)

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Stennis Space Center(SSC)	Lead Organization	NASA Center	Stennis Space Center, Mississippi

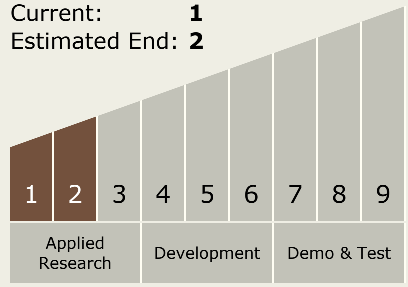
Primary U.S. Work Locations
Mississippi

Images

Potential Subscale Test-Site Location
Potential Subscale Test-Site Location
(https://techport.nasa.gov/image/2785)

Technology Maturity (TRL)

Start: **1**
Current: **1**
Estimated End: **2**



Technology Areas

Primary:

- TX01 Propulsion Systems
  └ TX01.1 Chemical Space Propulsion
    └ TX01.1.2 Earth Storable

Stories

REVIEW OF NUCLEAR THERMAL PROPULSION GROUND TEST OPTIONS
(https://techport.nasa.gov/file/21938)